

# Effect of carbamide peroxide and neutral fluoride on enamel surface

**Roberta de Azambuja Tagliari**  
**Eduardo Galia Reston**  
**Alcebiades Nunes Barbosa**  
**Ricardo Prates Macedo**

## ABSTRACT

This study evaluated the effect of a 10% carbamide peroxide gel on enamel surface and the remineralizing capacity of neutral fluoride applied either during or after bleaching treatment. Sixteen fragments were obtained from four extracted human teeth (incisors and molars) and assigned to four groups. Group I served as the control and groups II, III and IV underwent daily 8-hour carbamide peroxide bleaching treatment for 2 weeks. Additionally, group III was treated with 2% neutral fluoride gel for 4 minutes/day, and group IV received one single application of fluoride gel at the end of the 2-week bleaching treatment. Specimens were examined under scanning electron microscopy (SEM). Micrograph analysis showed that the bleaching gel caused changes to the enamel surface and that the application of neutral fluoride gel during or after treatment did not completely reverse the changes caused by bleaching. Carbamide peroxide increased enamel porosity. Application of neutral fluoride gel during or after the treatment did not produce any significant decrease in enamel porosity. Total enamel recovery seems to be more strongly associated with the buffering properties of saliva than with the use of different fluoride application protocols.

**Keywords:** Tooth bleaching, peroxide, fluoride.

## Efeito do peróxido de carbamida e do flúor neutro sobre a superfície do esmalte

### RESUMO

Este estudo avaliou o efeito de um gel de peróxido de carbamida a 10% sobre a superfície do esmalte e a capacidade de remineralização da aplicação de flúor neutro durante e após o tratamento de clareamento. Dezesesseis fragmentos foram obtidos de quatro dentes humanos extraídos (incisivos e molares) e distribuídos em quatro grupos. O grupo I serviu como controle, e os grupos II, III e IV foram submetidos a 8 horas diárias de clareamento com peróxido de

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**Roberta de Azambuja Tagliari** – MSc candidate, Universidade Luterana do Brasil (ULBRA), Canoas, RS, Brazil.

**Eduardo Galia Reston** – PhD in Cosmetic Dentistry – UNESP, Brazil. Professor, Faculty of Dentistry, ULBRA, Canoas, RS, Brazil.

**Alcebiades Nunes Barbosa** – PhD in Cosmetic Dentistry – FOB, Brazil. Professor, Faculty of Dentistry, ULBRA, Canoas, RS, Brazil.

**Ricardo Prates Macedo** – PhD in Cosmetic Dentistry – UNESP, Brazil. Professor, Faculty of Dentistry, ULBRA, Canoas, RS, Brazil.

Corresponding author: Roberta de Azambuja Tagliari. Rua Benjamin Constant 454/801, bairro Centro. CEP 99010-130 – Passo Fundo, RS – Brasil. Tel.: +55 (54) 3313.3925. E-mail: rtagliari@gmail.com

Stomatol	Canoas	Vol. 17	Nº 33	p.60-70	July/Dec. 2011
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carbamida durante 2 semanas. O grupo III foi tratado com gel de flúor neutro a 2% por 4 minutos diariamente, e o grupo IV recebeu uma aplicação de flúor ao final de 2 semanas de tratamento clareador. Os espécimes foram examinados sob microscopia eletrônica de varredura (MEV). A análise das fotomicrografias mostrou que o gel clareador causou alterações na superfície do esmalte e que a aplicação do gel de flúor neutro durante ou após o tratamento clareador não reverteu completamente as alterações causadas pelo procedimento clareador. O peróxido de carbamida aumentou a porosidade do esmalte. A aplicação de gel de flúor neutro durante ou depois do tratamento não produziu um aumento significativo na porosidade do esmalte. A recuperação total do esmalte parece estar mais associada com a capacidade tampão da saliva do que com o uso de diferentes protocolos de aplicação de flúor.

**Palavras-chave:** Clareamento dental, peróxido, flúor.

## INTRODUCTION

The search for a younger and more pleasant appearance is currently a widespread concern, and many patients seek dental bleaching treatments to obtain an esthetic smile, which is understood as synonymous with health.

Although tooth whitening techniques have been known since the 19th century, tooth bleaching was not used extensively until recently. A review of the literature on the history, safety and effectiveness of current bleaching techniques (1) revealed that the first documented use of tooth whitening agents dated back to the mid 1800s and described the use of oxalic acid. Shortly after, in 1884, the first report of the use of peroxide as a bleaching agent was published. In 1895, the use of pyrozone mouth rinsing (25% hydrogen peroxide and ether at a 5:1 ratio) was found to cause bleaching of vital teeth as a side effect. In 1937, the associated use of a heated instrument to speed up the bleaching process was suggested. In 1962, patients who were prescribed the Gly-oxide antiseptic solution (containing 10% carbamide peroxide) for use as a mouth rinse also experienced tooth whitening. In 1989, Haywood and Heymann (2) reported on a vital bleaching technique in which patients used a night guard with 10% carbamide peroxide gel. Thereafter, the use of 10% carbamide peroxide has become widespread worldwide as an effective tooth bleaching treatment (3).

The mechanism of action of bleaching agents is based on the oxidation of macromolecules responsible for enamel and dentin pigments. The permeability of dental structures provides free access of carbamide peroxide through the enamel and dentin organic matrix (4,5). These agents can bleach teeth that are stained with either extrinsic or intrinsic pigments (congenital or traumatic etiology).

The findings of a previous study using scanning electron microscopy (SEM) showed that the use of 10% carbamide peroxide for 5 weeks did not cause changes in enamel texture or surface topography and that the effects of the bleaching process extended to tooth portions that were not in direct contact with the gel (2). However, topographic changes, enamel porosity, absence of an enamel prism pattern, changes in calcium, phosphate and potassium levels in the hard tissues and decreased enamel microhardness have been reported after dental exposure to carbamide peroxide bleaching agents (1,4,6-10). Other

studies show that saliva has a buffering capacity that is responsible for increasing enamel microhardness and that the pH of saliva increases during the treatment (11).

Bleaching therapies change the permeability of tooth structures, making them more porous and vulnerable to the penetration of substances, bacteria and stains (12-14). Fluoride penetrates the dental tubules and forms insoluble calcium fluoride crystals, which promote desensitization and remineralization of dental tissues (14).

When evaluating the remineralizing capacity of different fluoride treatments on carbamide peroxide-bleached enamel, Attin et al. (15) found that bleaching caused a significant decrease in enamel hardness and that nonfluoridated bleached enamel presented greater hardness loss when compared with fluoridated bleached enamel. The authors concluded that the remineralization of bleached enamel is improved by the application of highly concentrated fluorides. Fluoride application after bleaching promotes remineralization of the enamel surface via the formation of apatite fluoride, which preserves enamel hardness and resistance to acid attacks. Fluoride also acts on dentin by depositing calcium fluoride, thus reducing the thermal sensitivity caused by bleaching (14-18).

The objective of this study was to assess the effect of a 10% carbamide peroxide gel on enamel surface and the remineralizing capacity of neutral fluoride applied either during or after the bleaching treatment.

## **MATERIALS AND METHODS**

Four human teeth (two maxillary central incisors and two mandibular molars), extracted for periodontal reasons were selected for this study. Teeth were stored at 4 °C in saline solution, which was changed weekly until the experiment began. Written informed consent was obtained from the patients for the donation and use of teeth for research purposes.

After cleaning with water/pumice slurry, the roots were removed with a water-cooled diamond disk at low speed. The incisor and molar crowns were bisected in both mesiodistal and incisogingival directions, thus resulting in four fragments per tooth. The 16 fragments were randomly assigned to four groups (n=4) and kept in plastic containers. Bleaching treatment lasted for 2 weeks, with an extra step after the second week for group IV, as follows: Group I, mesioincisal incisor and mesiobuccal molar fragments served as controls and were stored in artificial saliva at 37 °C, changed daily throughout the experiment; Group II, distoincisal incisor and distobuccal molar fragments were treated with 10% bleaching gel (Whiteness Perfect, FGM, Joinville, SC, Brazil) for 8 hours/day and stored in artificial saliva at 37 °C (changed daily) for the remaining 16 hours of each day; Group III, distocervical incisor and distolingual molar fragments were treated with 10% bleaching gel (Whiteness Perfect, FGM, Joinville, SC, Brazil) for 8 hours/day, followed by application of a transparent 2% neutral sodium fluoride gel (SS White, Rio de Janeiro, RJ, Brazil) for 4 minutes, and then stored in artificial saliva at 37 °C (changed

daily) for the rest of the day. Group IV, mesiocervical incisor and mesiolingual molar fragments were treated with 10% bleaching gel (Whiteness Perfect, FGM, Joinville, SC, Brazil) for 8 hours/day and stored in artificial saliva at 37 °C (changed daily) for the remaining 16 hours. However, in group IV, at the end of the second week of bleaching treatment, fragments were additionally treated with 2% neutral sodium fluoride gel (SS White, Rio de Janeiro, RJ, Brazil) for 4 minutes (one session only).

The bleaching agent was a 10% carbamide peroxide gel, with neutral pH, containing potassium ions, glycol, as well as potassium nitrate and sodium fluoride as desensitizing agents. The bleaching gel was removed from the specimens with a toothbrush under running water. Excess fluoride was eliminated using water-soaked gauze.

Once the treatment protocol was concluded, specimens were examined with a scanning electron microscope (XL20, Philips Electronics NV, Eindhoven, Netherlands) to detect morphological changes on the enamel surface of specimens in the four groups. SEM micrographs were taken at X1000 magnification and analyzed to compare the effect of treatment on enamel in each group.

## RESULTS

The analysis of SEM micrographs revealed differences on the enamel surface in the comparison of specimens before bleaching (Figures 1 and 2) and after the 8-hour daily bleaching regimen maintained over a 2-week period, with an increase in enamel surface porosity (Figures 3 and 4).

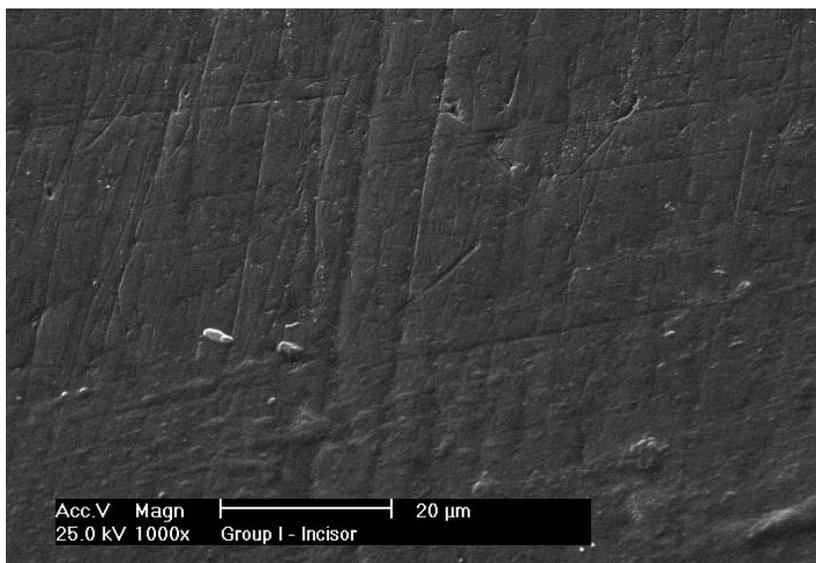


FIGURE 1. Group I, incisor, enamel surface before bleaching (X1000 magnification).

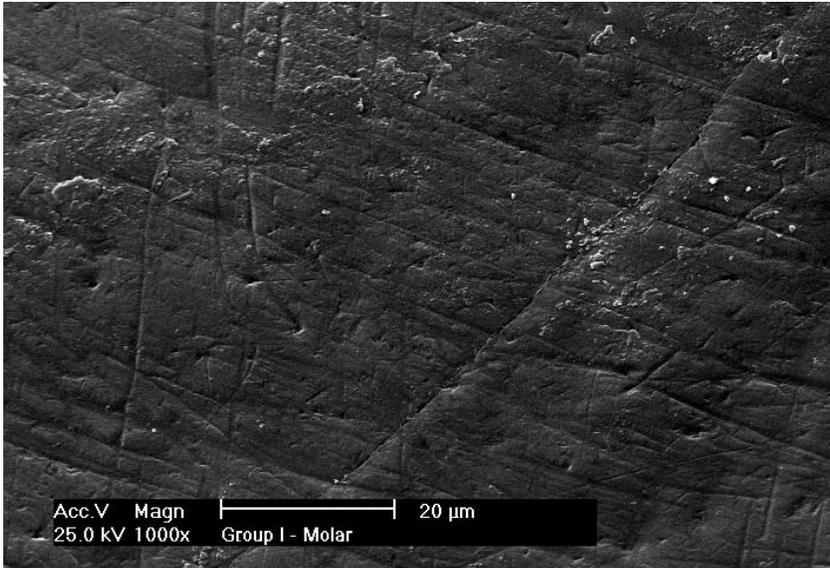


FIGURE 2. Group I, molar, enamel surface before bleaching (X1000 magnification).

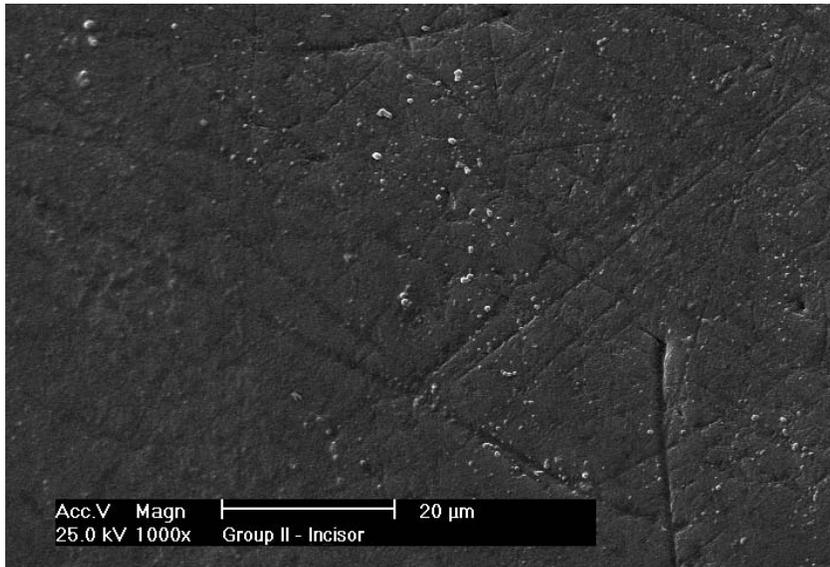


FIGURE 3. Group II, incisor, increased enamel surface porosity after bleaching (X1000 magnification).

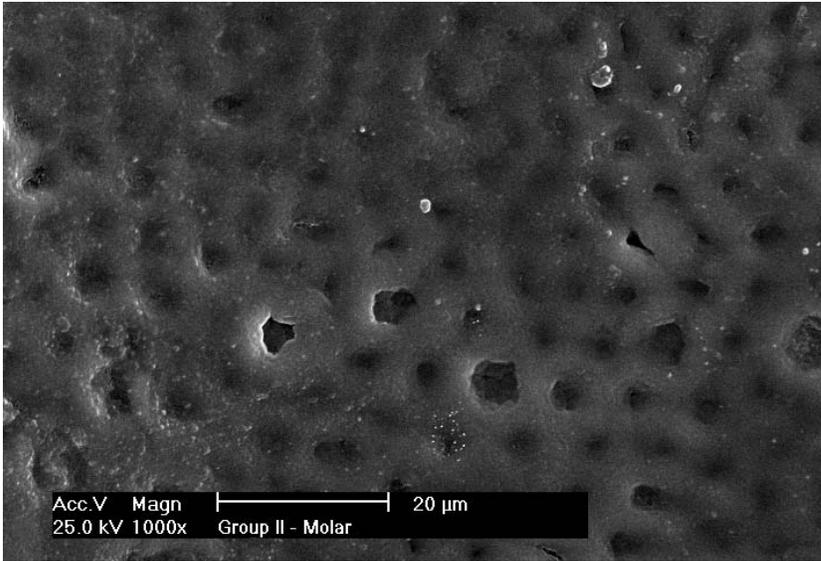


FIGURE 4. Group II, molar, increased enamel surface porosity after bleaching (X1000 magnification).

Figures 5 and 6 show enamel surfaces after a 2-week bleaching treatment combined with 4-minute applications of 2% neutral fluoride gel after each bleaching session.

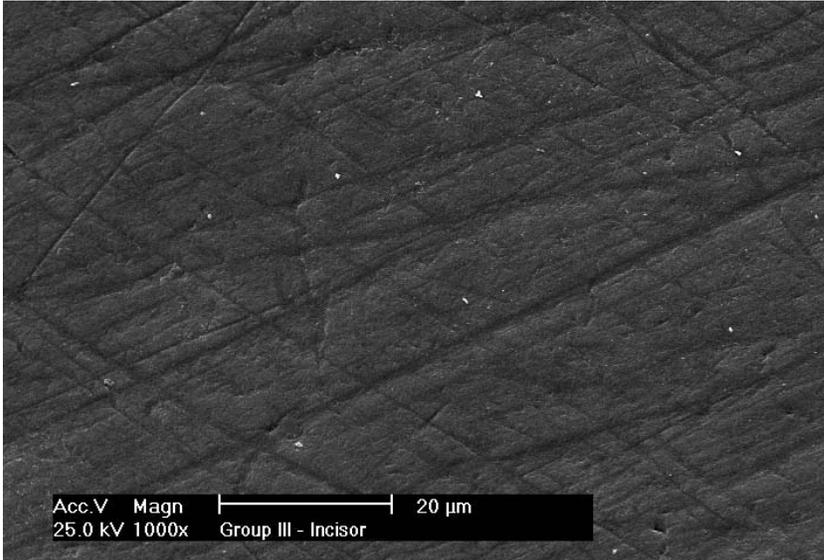


FIGURE 5. Group III, incisor, enamel surface after 2-week bleaching treatment combined with 4-minute applications of 2% neutral fluoride gel after each bleaching session (X1000 magnification).

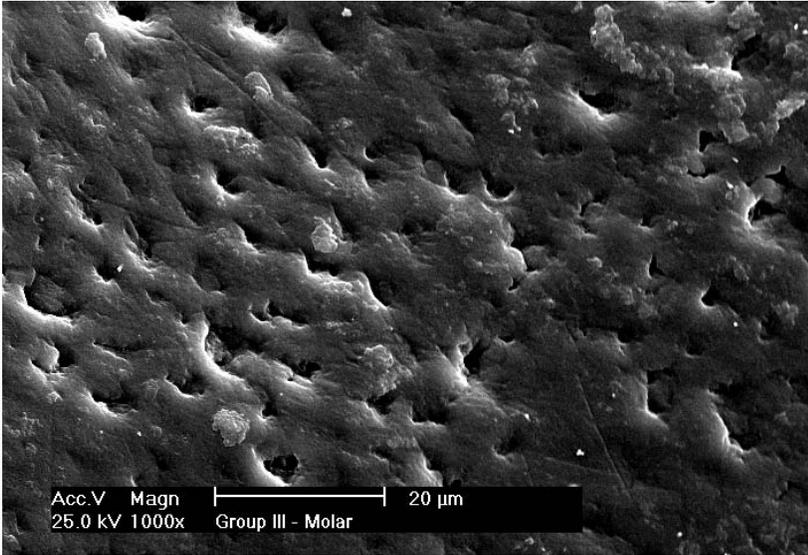


FIGURE 6. Group III, molar, enamel surface after 2-week bleaching treatment combined with 4-minute applications of 2% neutral fluoride gel after each bleaching session (X1000 magnification).

Figures 7 and 8 show enamel surfaces that underwent bleaching and received one single application of fluoride gel at the end of the 2-week bleaching protocol.

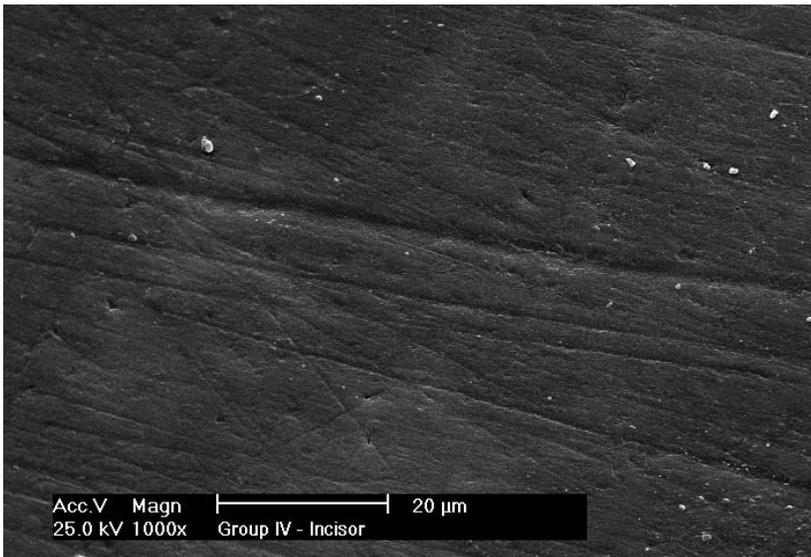


FIGURE 7. Group IV, incisor, enamel surface after 2 weeks of bleaching plus one single application of fluoride gel at the end of treatment (X1000 magnification).

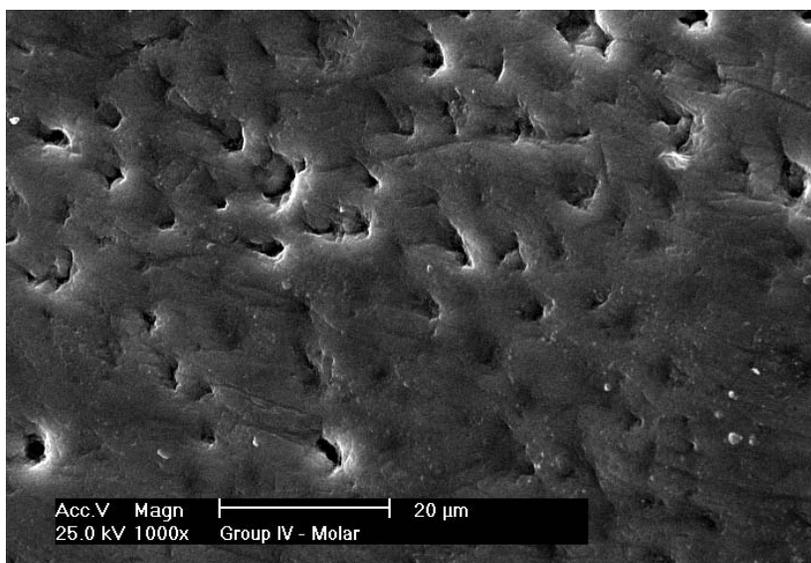


FIGURE 8. Group IV, molar, enamel surface after 2 weeks of bleaching plus one single application of fluoride gel at the end of treatment (X1000 magnification).

The application of neutral fluoride gel during or after the bleaching treatment did not completely reverse the changes caused by bleaching. No significant differences were observed between the daily application of fluoride gel vs. the application of one single dose of fluoride.

## DISCUSSION

Patients are increasingly concerned with having whiter teeth, and esthetic dentistry has been focused on the development of minimally invasive techniques that allow to meet this demand. Among such techniques, perhaps the most popular and widely used one is tooth bleaching, both at home and in the office (19).

Ten percent carbamide peroxide has been widely used in at-home bleaching treatments. Haywood and Heymann (19) have introduced the technique in which a 0.5-mm-thick guard is used overnight to keep the gel in contact with the teeth for 4 to 6 hours over a 2- to 5-week period.

Evidence shows that 10% carbamide peroxide causes changes on enamel surface and that sodium fluoride is indicated as an adjuvant treatment to minimize the sensitivity caused by carbamide peroxide bleaching. The present study was designed to investigate changes in enamel properties caused by bleaching and whether such changes are affected by the application of neutral sodium fluoride gel either during the treatment or at the end of the bleaching protocol.

Experimental studies have described changes in the texture of bleached enamel. Although Haywood et al. (2) have found no changes in enamel texture or topography after treatment with 10% carbamide peroxide, McGucking et al. (20) and Groebler et al. (10) measured the pH of several commercial brands of tooth bleaching agents and observed that all products produced enamel porosities, in spite of a neutral or non-neutral pH. Other studies (12-14,21) have also reported changes the enamel surface, such as increased porosity and altered prism structure. Finally, previous SEM studies (7,22) have shown significant surface changes in enamel topography after a 4-week bleaching protocol, especially when low pH bleaching gels were used.

The comparison between specimens that received and those that did not receive fluoride treatment in our sample revealed that fluoride application did not promote significant enamel recovery. Despite a decrease in pore size, the porosity pattern remained in all groups. Attin et al. (15), Martin et al. (22) and Borges et al. (18) have tested different types of fluoride for the remineralization of bleached enamel. All those authors concluded that the application of high concentrations of fluoride significantly increased enamel hardness, and recommended the application of fluoride after exposure to bleaching agents to promote enamel remineralization. However, the findings of our study suggest that the remineralizing effect of topical fluoride on the bleached enamel is neutralized by a new application of the bleaching gel. Similarly, a single application of fluoride at the end of treatment failed to provide any significant gain in terms of bleached enamel recovery.

Finally, the comparison between incisor and molar fragments showed that the enamel from these teeth responded differently to the bleaching treatment. SEM micrographs revealed that porosities were more evident on the enamel of molar teeth, suggesting that this tooth may be more porous originally. These results are in agreement with a previous investigation (7) that also used incisors and molars and reported a similar appearance for bleached enamel as observed in our study.

## CONCLUSIONS

The SEM examination of 10% carbamide peroxide-bleached enamel surfaces revealed that this bleaching agent increased enamel porosity, as expected. Moreover, the daily application of neutral fluoride gel during the treatment did not produce significant reductions in enamel porosity, and the use of neutral fluoride gel at the end of the bleaching protocol was not able to completely reverse the changes on enamel surface.

Our findings seem to suggest that total enamel recovery may occur regardless of fluoride application, and that it is more likely to be associated with the buffering properties of saliva. Further studies should be conducted with different materials and compositions to corroborate or confront these outcomes.

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